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DESCRIPTION

OF A

PIECE OF MECHANISM,

ON THE

SUPPOSED PRINCIPLE OF MUSCULAR ACTION,

Read, and Model exhibited, before the Medico-Chirurgical Society, Aberdeen, July 6, 1848,

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DESCRIPTION OF A PIECE OF MECHANISM,

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HAVING several years ago had an opportunity of seeing a number of electro-motive machines of various constructions, I was much struck by observing the extreme weakness of the power rendered available for practical purposes by the different mechanical arrangements employed, compared with the tremendous force actually exerted, under certain circumstances, by the moving power made use of. An electro-magnet, which would, within its proper sphere of power, attract to itself, and retain suspended, a weight of many tons, could not be made by any of the arrangements I saw employed, to perform the twentieth part of the labour of one horse.

I shall not occupy your time by describing what those arrangements were, as most of you have seen them as well as myself, but come at once to the description of one upon an entirely new principle, which I have carried into effect with the happiest result, and of which the idea was suggested by the mode in which the muscular force appears to be exerted in that microcosm or little world,—our own body, the proper study of which I believe to be capable of affording the key to many hitherto unsolved problems in various departments of science.

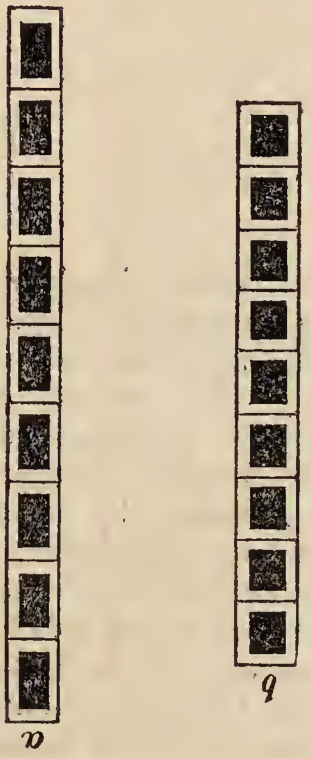
It has for some time been a current belief in physiology, that the contraction of muscles is produced by the mutual attraction of minute cells or globules, arranged in parallel lines, of which the ultimate fibrils of the muscular tissue consist. The stimulus that excites this attraction, is the vital electricity, or the nervous or bio-galvanic current, transmitted by the nerves, and brought to bear upon the muscular globules by means of the ultimate nervous filaments, which interlace among them, and form a network of anastomoses, so as to complete the circle or current of nervous influence, of which the fountain, or, at all events, the prime-motor, is the brain or spinal marrow. The aggregate of these minute movements gives the extent of contraction of the entire muscle; the combined force of these molecular attractions, its full power or strength.

The following extracts and figures from Dr. Carpenter's "Manual of Physiology," will place the subject more clearly before us:—

At p. 200, he says, "When the fibrillæ are separately examined under a high magnifying power, they are seen to present a cylindrical or slightly beaded form, and to be made up of a linear aggregation of distinct cells. We observe the same alternation of light and dark spaces as when the fibrillæ are united into fibres or into small bundles; but it may be distinctly seen, that each light space is divided by a transverse line, and that there is a pellucid border at the *sides* of the dark spaces as well as between their contiguous extremities.

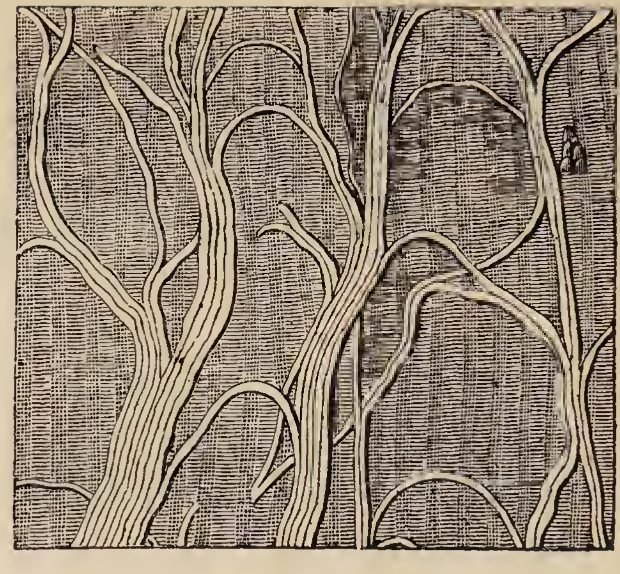
"This pellucid border seems to be the

cell-wall: the dark space enclosed by it (which is usually bright in the centre), being the cavity of the cell, which is usually filled with a highly refracting substance. When the fibril is in a state of relaxation as seen at *a*, the diameter of the cells is greatest in the longitudinal direction; but when it is contracted, the fibril increases in diameter as it diminishes in length,—so that the transverse diameter of each cell becomes equal to the longitudinal diameter as seen at *b*, or even exceeds it.



"The diameter of the ultimate fibrillæ will of course be subject to variations in accordance with the contracted or relaxed condition; but it seems to be otherwise tolerably uniform in different animals, being for the most part about 1-10,000th of an inch. The average distance of the striæ, too, is nearly uniform — about 1-10,000th of an inch in different animals, though considerable variations present themselves in every individual, and in different parts of the same muscle."

On the subject of the arrangement of the nerves and tendons in connection with muscles, the same authority says, p. 203, "The muscles of animal life are, of all animal tissues except the skin, the most copiously supplied with nerves. These, like the blood-vessels, lie on the outside of the myolemma of each fibre, and their influence must consequently be exerted through it. The arrangement of these nerves is shewn in the annexed figure. Their ultimate fibres or tubes cannot be said to terminate anywhere in the muscular substance; for, after issuing from the trunks, they form a series of loops, which either return to the same trunk or join an adjacent one. The occasional appearance of the termination of a nervous fibril is caused by its dipping down between the muscular fibres, to pass towards another stratum.

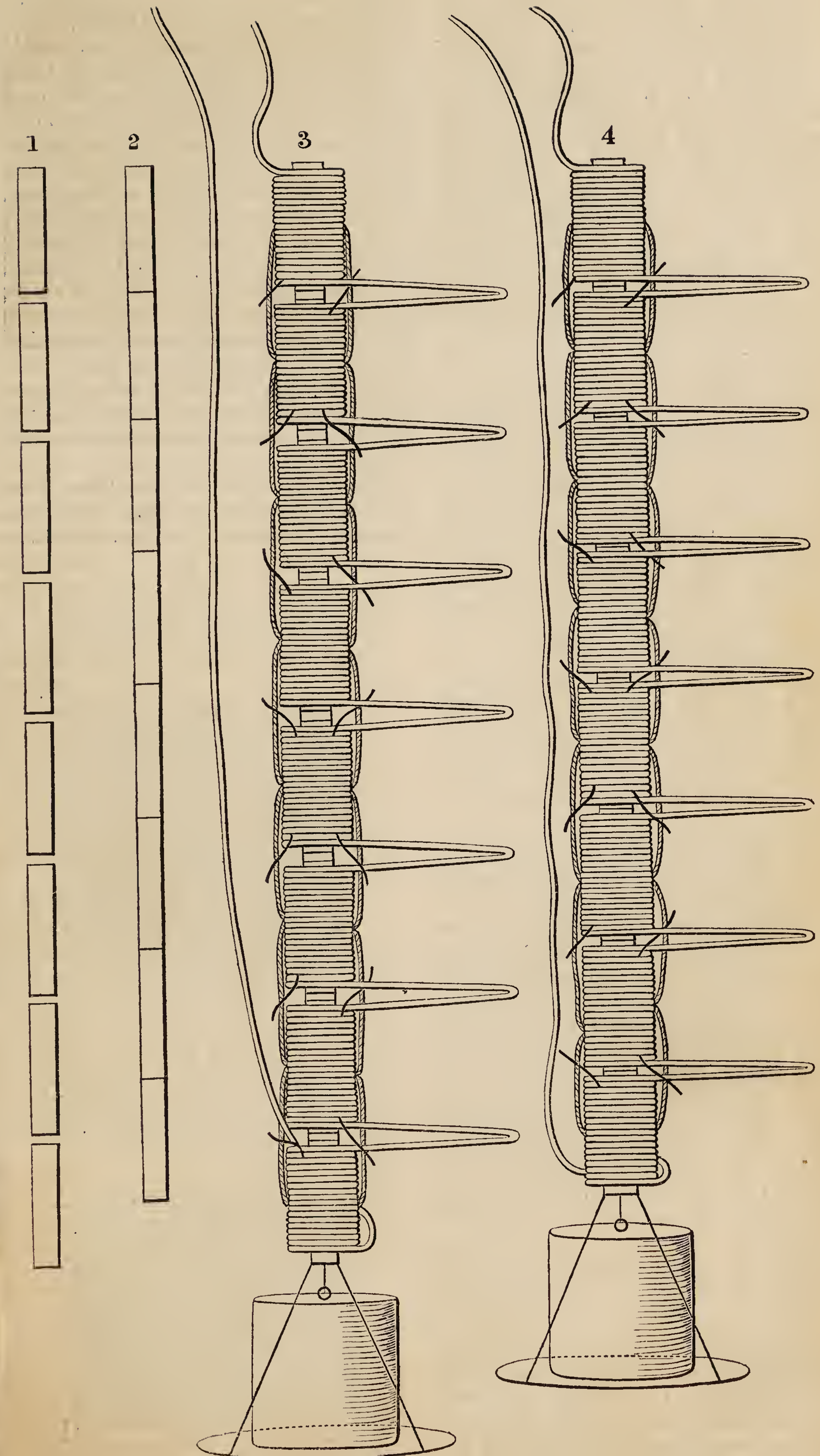


"Every muscular fibre, of the striated kind at least, is attached at its extremities to fibrous tissue, through the medium of which it exerts its contractile power on the bone or other substance which it is destined to move. Thus the whole muscle is penetrated by minute fasciculi of tendinous fibres, and these collect at its extremities into a tendon."

Of the anatomical arrangement now described, the electro-motive machine I have constructed is as close an imitation as possible: it consists of a number of electro-magnets opposed endwise to one another, arranged in parallel lines, and connected together by fastenings in such a way that, when made to act simultaneously, their united force can be brought to bear upon one point.

The annexed figures will give an idea of the apparatus both in a state of repose and of action, or, to speak analogically, in the opposite states of relaxation and contraction.

Fig. 1 represents a series of eight rectangular prisms of soft iron, one and one-eighth of an inch long, by a quarter of an inch square, placed endwise, at the distance of one-twelfth of an inch from one another. Fig. 2 shews the same in close contact. Figs. 3 and 4 represent the prisms in the



same relative position, but armed with a continuous covered copper wire, and connected together in such a manner as to admit of free motion within a limited extent. Each prism has covered wire, about 1-20th of an inch thick, wrapped round it closely and regularly, in three layers, and, before being carried to the next prism or magnet, the wire is extended out for about an inch and a half at right angles to the prism, and bent back again at an acute angle, by which means the resistance it offers to the motion of the magnets is almost entirely overcome.

The prisms or magnets, with their opposite poles opposed to each other, are connected together by ligaments of catgut, the length of which can be so graduated, by twisting them by means of a small pin (which can be fixed by having its end inserted among the wire), that any distance that may be necessary can be assigned as the limit of motion to the magnets. It is proper to mention that the prisms are all bound together by two bands of vulcanized Indian rubber, in close contact with their opposite sides, and sufficiently on the stretch to overcome entirely the weight with which, when hanging perpendicularly, one part of the apparatus would bear upon the other.

The advantage of the arrangement now described is, that as the same current of galvanism is equally efficient in rendering many prisms magnetic as one, and as the motions produced by the magnetic influence are, by the way in which the prisms are in the apparatus connected together, communicated from the one to the other, and all accumulated or brought to bear at the end of the series, the amount of power gained is just the attractive power of one prism multiplied by the number in the series, deducting, of course, the resistance to be overcome by moving the additional number of magnets.*

Supposing one electro-magnet to be capable of raising three pounds one-twelfth of an inch, by combining 96 of them into one chain or series, in the way shewn in the model, there would be attained a power of raising three pounds a distance of $\frac{96}{12}$ of an inch, or eight inches; but allowing the additional magnets and their appendages to weigh one pound, and to be provided with no counterbalancing arrangement, then it is evident that the actual power attained would be only that of raising two pounds a height of eight inches. But, by combining 100 such columns, each containing 96 magnets, there would be attained a power of raising 200 pounds eight inches, or 100 pounds sixteen inches, or fifty pounds thirty-two inches, &c. according to the manner in which the combination was made.

Figures 5 and 6 shew how the chains of magnets might be combined into a compound machine: one end of them

Fig. 5.

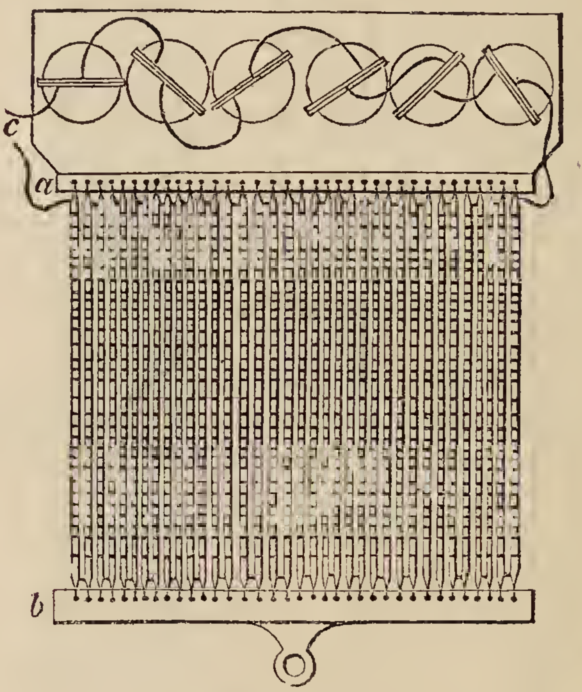
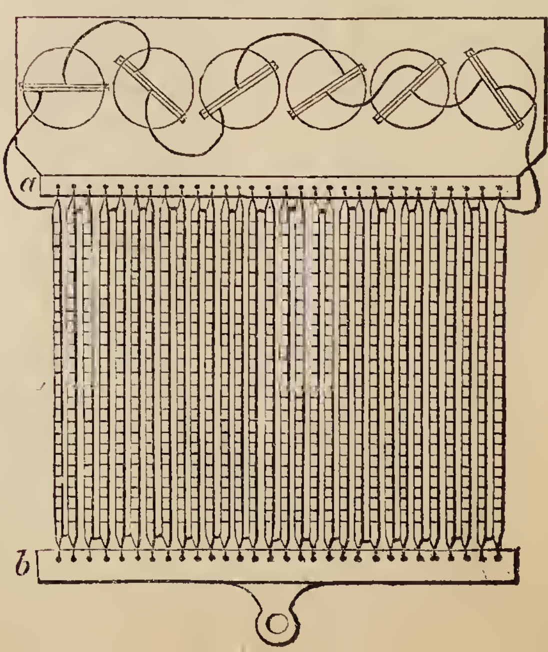


Fig. 6.



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* The apparatus above described, which weighs five and a half ounces, with the aid of a moderate battery lifts a pound and a half a distance of nearly half an inch. Its action is almost instantaneous; and the shock with which it becomes rigid or relaxed, as the stimulus is applied or withdrawn, reminds one very forcibly of the spasmodic action of a muscle.

being attached to the fixed beam *a* near which the battery (in this instance a Smee's of six jars) is placed, their other extremities being fixed to the moveable beam *b*, from which any motion required could be easily taken. In fig. 5 the magnets are in a relaxed state, their connection with the battery being broken; while in fig. 6 they are in a state of contraction, the circuit of wire which connects them with the battery being complete.

By combining a number of such frames together, all connected by the same wire, and by augmenting the strength of the battery, any degree of power might be obtained, and, as in the steam-engine, the apparatus might be easily made self-governing in its action, by having a small cup of mercury with which one of the wires was connected, placed, say at *c*, fig. 5: the other end of the wire could be made alternately to dip into it and emerge from it, by means of a pendulum, so as to break and restore the connection, and thus keep the machine going with any degree of frequency that might be required.

Various expedients might be employed to neutralize or counterbalance the weight of the apparatus, if the power to be thus gained were thought a sufficient object. Thus, the magnets, supposing them to hang perpendicularly, might be articulated together by elastic ligaments (as in the model on the table) strong enough to overcome their weight, and no more; or they might, if placed horizontally, be provided with small wheels, and made to move in a sort of railway.

Upon the whole, it is evident that the power of such an apparatus would depend upon the perfection of its mechanism, and upon the fidelity with which it could be made to imitate the model which Almighty Wisdom has presented to us in the muscular structure and action. And, as the force of the attraction of electro-magnets increases prodigiously as their distance diminishes, (inversely as the square of the distance?) it follows that the smaller and more numerous the component magnets of the machine could be made, the greater would be the power attained. But in this respect, it is not to be expected that human ingenuity could ever be able to reach, by many hundred, I might say thousand, degrees, the minuteness of the muscular tissue. Yet even if the motive power attained were only a five-hundredth part of that which muscle *can be made to exert*, in proportion to the weight of the apparatus, this would be a very great advance upon the results that have hitherto been arrived at in this department.

Though, undoubtedly, it will be long before electricity be brought to supersede, or even to compete with, steam as a source of mechanical power, yet such a result need not be looked upon as chimerical, after the extraordinary properties it has been discovered to be possessed of, and the wonders we have seen effected by it, within the last few years.

Another necessary step towards this consummation, besides the perfecting of the mechanical arrangement, would be the discovery of a cheap source of galvanism; one whose price would not exceed that of the fuel employed in the production of steam. But that the very same source from which steam is obtained may be made available for the generation of electricity, is proved by recent experiments; though whether in a form suitable as a source of electro-motive power, yet remains to be ascertained.

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